CLAIMS

What is claimed is:

1. A droplet ejection apparatus comprising:

a plurality of droplet ejection heads, each of the droplet ejection heads including:

a diaphragm;

an actuator which displaces the diaphragm;

a cavity filled with a liquid, an internal pressure of the cavity being increased and decreased in response to displacement of the diaphragm; and

a nozzle communicated with the cavity, through which the liquid is ejected in the form of droplets in response to the increase and decrease of the internal pressure of the cavity;

a driving circuit which drives the actuator of each droplet ejection head;

pulse generating means for generating reference pulses;

a counter for counting the number of reference pulses generated for a predetermined time period; and

ejection failure detecting means for detecting an ejection failure of the droplets on the basis of the count value of the counter counted for the predetermined time period.

2. The droplet ejection apparatus as claimed in claim 1, wherein the predetermined time period is a time period until a residual vibration of the diaphragm displaced by the actuator is generated after the droplet has been normally ejected from the droplet ejection head.

3. The droplet ejection apparatus as claimed in claim 1, wherein the predetermined time period is a time period corresponding to a first half cycle of the residual vibration.

4. The droplet ejection apparatus as claimed in claim 1,

wherein the predetermined time period is a time period corresponding to a first one cycle of the residual vibration.

5. The droplet ejection apparatus as claimed in claim 1, wherein the ejection failure detecting means detects presence or absence of the ejection failure by comparing a normal count range of the reference pulses when a droplet is normally ejected by the driving of the actuator with a count value of the counter counted for the predetermined time period.

6. The droplet ejection apparatus as claimed in claim 5, wherein the ejection failure detecting means judges that an air bubble has been intruded into the cavity as a cause of the ejection failure in the case where the count value is smaller than the normal count range.

7. The droplet ejection apparatus as claimed in claim 5, wherein the ejection failure detecting means judges that the liquid in the vicinity of the nozzle has thickened due to drying or that paper dust is adhering in the vicinity of the outlet of the nozzle as a cause of the ejection failure in the case where the count value is larger than the normal count range.

8. The droplet ejection apparatus as claimed in claim 1, wherein the counter subtracts the number of reference pulses counted for the predetermined time period from a predetermined reference value, and the ejection failure detecting means detects the ejection failure on the basis of the subtraction result.

9. The droplet ejection apparatus as claimed in claim 8, wherein the ejection failure detecting means judges that an air bubble has intruded into the cavity as a cause of the ejection failure in the case where the subtraction result is smaller than a first threshold.

10. The droplet ejection apparatus as claimed in claim 8, wherein the ejection failure detecting means judges that the liquid in the vicinity of the nozzle has thickened due to drying as a cause of the ejection failure in the case where the subtraction result is larger than a second threshold.

11. The droplet ejection apparatus as claimed in claim 10, wherein the ejection failure detecting means judges that paper dust is adhering in the vicinity of the outlet of the nozzle as a cause of the ejection failure in the case where the subtraction result is smaller than the second threshold and larger than a third threshold.

12. The droplet ejection apparatus as claimed in claim 1, further comprising storage means for storing the detection result detected by the ejection failure detecting means.

13. The droplet ejection apparatus as claimed in claim 1, further comprising switching means for switching a connection of the actuator from the driving circuit to the ejection failure detecting means after carrying out a droplet ejection operation by driving the actuator.

14. The droplet ejection apparatus as claimed in claim 1, wherein the ejection failure detecting means includes an oscillation circuit and the oscillation circuit oscillates in response to an electric capacitance component of the actuator that varies with the residual vibration of the diaphragm.

15. The droplet ejection apparatus as claimed in claim 14, wherein the ejection failure detecting means includes a resistor element connected to the actuator, and the oscillation circuit forms a CR oscillation circuit based on the electric capacitance component of the actuator and a resistance component of the resistor element.

16. The droplet ejection apparatus as claimed in claim 14, wherein the ejection failure detecting means includes an F/V converting circuit that generates a voltage waveform in response to the residual vibration of the diaphragm from a predetermined group of signals generated based on changes in an oscillation frequency of an output signal from the oscillation circuit.

17. The droplet ejection apparatus as claimed in claim 16, wherein the ejection failure detecting means includes a waveform shaping circuit that shapes the voltage waveform in response to the residual vibration of the diaphragm generated by the F/V converting circuit into a predetermined waveform.

18. The droplet ejection apparatus as claimed in claim 17, wherein the waveform shaping circuit includes: DC component eliminating means for eliminating a direct current component from the voltage waveform of the residual vibration of the diaphragm generated by the F/V converting circuit; and a comparator that compares the voltage waveform from which the direct current component thereof has been eliminated by the DC component eliminating means with a predetermined voltage value; and

wherein the comparator generates and outputs a rectangular wave based on this voltage comparison.

19. The droplet ejection apparatus as claimed in claim 1, wherein the actuator includes an electrostatic actuator.

20. The droplet ejection apparatus as claimed in claim 1, wherein the actuator includes a piezoelectric actuator having a piezoelectric element and using a piezoelectric effect of the piezoelectric element.

21. The droplet ejection apparatus as claimed in claim 1, wherein the droplet ejection apparatus includes an ink jet printer.

22. A droplet ejection apparatus comprising:

a plurality of droplet ejection heads, each of the droplet ejection heads including:

a cavity filled with a liquid;

a nozzle communicated with the cavity; and

a piezoelectric actuator for varying a pressure of the liquid filled in the cavity, the liquid being ejected through the nozzle in the form of droplets in response to the variation of the pressure;

a driving circuit which drives the piezoelectric actuator of each droplet ejection head;

pulse generating means for generating reference pulses;

a counter for counting the number of reference pulses generated for a predetermined time period; and

ejection failure detecting means for detecting an ejection failure of the droplets on the basis of the count value of the counter counted for the predetermined time period.

23. The droplet ejection apparatus as claimed in claim 22, wherein the predetermined time period is a time period until the residual vibration of an electromotive voltage of the piezoelectric actuator is generated after the droplet has been normally ejected from the droplet ejection head.

24. The droplet ejection apparatus as claimed in claim 22, wherein the droplet ejection apparatus includes an ink jet printer.

25. A method of detecting an ejection failure in droplet ejection heads, each of the droplet ejection heads including a diaphragm, an actuator, a cavity and a nozzle, the method comprising the steps of:

carrying out a droplet ejection operation in which a liquid in the cavity is ejected through the nozzle in the form of droplets by displacement of the diaphragm by driving the

actuator;

generating reference pulses and measuring a predetermined time period after the droplet ejection operation;

counting the number of reference pulses generated for the measured predetermined time period; and

detecting an ejection failure of the droplets on the basis of the count value in the counting step.

26. The method as claimed in claim 25, wherein the counting step includes subtracting the number of reference pulses counted for the predetermined time period from a predetermined reference value; and

wherein the ejection failure detecting step includes detecting the ejection failure on the basis of the subtraction result.

27. A method of detecting an ejection failure in droplet ejection heads, each of the droplet ejection heads including a cavity, a nozzle and a piezoelectric actuator, the method comprising the steps of:

carrying out a droplet ejection operation in which a liquid in the cavity is ejected through the nozzle in the form of droplets by driving the piezoelectric actuator;

generating reference pulses and measuring a predetermined time period after the droplet ejection operation;

counting the number of reference pulses generated for the measured predetermined time period; and

detecting an ejection failure of the droplets on the basis of the count value in the counting step.